FTIR Micro-tomography of five Itokawa Particles

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Primitive extra-terrestrial materials (asteroidal and cometary particles, meteorites, IDPs) are characterized by a large mineralogical and compositional heterogeneity at different scales (from nm to mm) [1], which witnesses the complexity of the pre-accretional (solar nebula) and post-accretional (parent bodies) processes undergone by the small bodies of our solar system [2]. This heterogeneity has been observed by different techniques such as infrared (IR) micro spectroscopy mapping which is a powerful tool as it is (a) non-destructive and allows (b) comparison with astronomical observations of primitive Solar System small bodies (asteroids, comets, TNOs) [3] and (c) access both to the mineral and carbonaceous phases.

Thanks to Focal Plane Array (FPA) detector, 3D hyperspectral micro-tomography, can be performed to access structural information on intact samples [4, 5]. So far, this technique has never been applied to Hayabusa-1. Here, we will present the first 3D infrared reconstruction of five particles of Itokawa (RA-QD02-0214, RA-QD02-0223, RA-QD02-0232, RA-QD02-0156 and RB-QD04-0046). The FTIR micro analyses are performed at the SMIS beamline of the Synchrotron SOLEIL using a FPA detector with its Globar intern source. It is complementary to the X-ray micro-tomography previously performed on Hayabusa-1 particles [6]. Novel numerical methods have been developed to deal with a huge quantity of hyperspectral infrared data and we were able to obtain the 3D spatial distribution of chemical/mineralogical components (low/high calcium pyroxene, olivine, and plagioclase).

Another analysis was performed on grains of the Paris meteorite, one of the most primitive carbonaceous chondrite [7], to study the spatial correlation between the organic and mineral phases at scales down to ~3 µm. X-rays tomography was also performed on the same Paris particles, at the PSICHE beamline of the synchrotron SOLEIL, to obtain complementary information about the physical properties of the grains (shape, fractures, porosity …). By combining X-ray and FTIR data we could obtain a physico-chemical description of precious grains in a non-destructive way and thus gives information about the formation and evolution of asteroids.

Performing FTIR micro-tomography on extraterrestrial samples rich in organic matter, is an important step in view of the sample return of dust particles from carbonaceous asteroid Ryugu by the Hayabusa-2 mission. In the sequence of analyses, micro-FTIR 3D spectral imaging coupled with X-rays tomography can provide a first, powerful non-destructive characterization of whole grains, in order to identify areas of interest and provide useful information before subsequent destructive analyses.

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